2739

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:

David P. Rossum

Application No.: 09/427,815

Filed: October 27, 1999

For: SAMPLE RATE CONVERTER
HAVING DISTRIBUTED FILTERING

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

The inventor has discovered an error in the application as filed. The error does not affect what is claimed, but affects the performance estimates set forth in the application. In particular, in estimating performance, the numbers set forth omitted to account for the fact that the Nyquist frequency of the unsampled filter was doubled. Set forth below are the changes necessary to correct the application.

The Examiner is requested to advise whether a new specification should be submitted or whether it can be amended. It is believed that it does not affect the substance of what is claimed, and thus is not necessary to maintain the filing date, but would simply make the ancillary performance discussion correct.

--Page 1 line 9, change last line in paragraph to end "called the Nyquist Frequency (F_n)." [Fn is F sub n].

Page 14, line 2 (about a page into the section "Sample Rate Converter") Old: Thus the width of the guard band has been increased from 4 kHz to 28 kHz, a factor of seven. With such a dramatically wider guard band, the transition width of the filter associated with interpolator 304 can be drastically increased and its complexity correspondingly reduced. For example, only a fourth order filter is required for 0.01 dB ripple and 96 dB stop-band...

New: Thus the width of the guard band has been increased from $1/6$ Fn to $7/12$ Fn, a factor of 3 1/2. With such a dramatically wider guard band, the transition width of the filter associated with interpolator 304 can be drastically increased and its complexity correspondingly reduced. For example, only an eighth order filter is required for 0.01 dB ripple and 96 dB stop-band... [Fn is F sub n here too.]

Change Table 1 to read:

8	0.01	-96	0.015	-96	0.021	-96	0.025	-96
10	0.001	-112	0.0014	-108	0.0023	-108	0.003	-108
12	0.000	-128	0.00014	-120	0.00025	-120	0.00035	-120
14	0.00001	-144	0.000014	-132	0.000025	-132	0.00004	-132
16	0.000001	-160	0.0000014	-144	0.0000023	-144	0.000004	-144

Change the paragraph after table 1, 2nd sentence from: "can be approximately halved compared to"

to: "can be somewhat reduced compared to" The paragraph on page 16 (just above heading "IIR Upsampling Filter where Linear Phase not Required" was:

For purposes of comparison, the preferred embodiment requires a 4th order interpolator and a 77th order half-band upsampling filter, for a total complexity of 19+8=27 multiplications and 38+12=50 additions, while the prior art classical algorithm requires a 28th order interpolator of complexity 56 multiplications and 84 additions to achieve the same specifications of 0.01 dB ripple and 96 dB stopband attenuation. An additional benefit of the preferred embodiment over the prior art is a reduction in the table size for the coefficients for the interpolator by a factor of seven.

Should be: For purposes of comparison, the preferred embodiment requires an 8th order interpolator and a 77th order half-band upsampling filter, for a total complexity of 19+16=35 multiplications and 38+24=62 additions, while the prior art classical algorithm
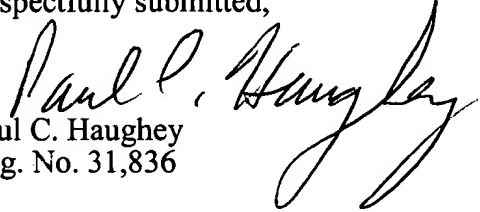
requires a 28th order interpolator of complexity 56 multiplications and 84 additions to achieve the same specifications of 0.01 dB ripple and 96 dB stopband attenuation. An additional benefit of the preferred embodiment over the prior art is a reduction in the table size for the coefficients for the interpolator by a factor of 3.5.

        The paragraph after table three was: As can be seen, very substantial gains in computational complexity derive from use of the IIR filter. A power symmetrical elliptical upsampling filter of order n requires n multiplicative operations and 3n additive operations for each input sample. Thus, for example, an implementation at 48 kHz with 0.0 1 dB ripple and 96 dB stopband rejection takes only a 4th order interpolator, and an order 6 IIR half-band upsampling filter. This requires 6+8 = 14 multiplicative operations and 18+12 = 30 additions, reducing multiplicative operations to 25%, and additive operations to 36%, of that required by the classical algorithm. At lower input rates, the efficiency is even higher. The phase non-linearity of the IIR filter can also be reduced by addition of a low order allpass stage with a compensating phase characteristic in series with the IIR filter. Fig. 9 shows such a compensating circuit, where first order allpass filter 901 partially compensates for the phase nonlinearity of power symmetric elliptical upsampling half-band filter 902.

        It should read: As can be seen, very substantial gains in computational complexity derive from use of the IIR filter. A power symmetrical elliptical upsampling filter of order n requires n multiplicative operations and 3n additive operations for each input sample. Thus, for example, an implementation at 48 kHz with 0.0001 dB ripple and 128 dB stopband rejection takes only a 12th order interpolator, and an order 8 IIR half-band upsampling filter. This requires 8+24 = 32 multiplicative operations and 24+36 = 60 additions. The classical approach requires order 43 to achieve the same specifications. The current invention thus reduces multiplicative operations to 37%, and additive operations to 40%, of that required by the classical algorithm. At lower input rates, the efficiency is even higher. The phase non-linearity of the IIR filter can also be reduced by addition of a low order allpass stage with a compensating phase characteristic in series with the IIR filter. Fig. 9 shows such a compensating circuit, where first order allpass filter 901 partially compensates for the phase nonlinearity of power symmetric elliptical upsampling half-band filter 902.--

      If the Examiner believes a telephone conference would expedite prosecution of this application, please telephone the undersigned at 650-326-2400.

Respectfully submitted,

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